U. S. Department of Agriculture, Forest Service

FOREST PRODUCTS LABORATORY

In cooperation with the University of Wisconsin

MADISON, WISCONSIN

FOREST PRODUCTS IN THE CHEMICAL INDUSTRIES

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July, 1924

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Many people do not realize the importance of the forests to chemical industry nor see the necessity for chemists in the Forest Service. To an audience of chemical engineers many connections between chemistry and forestry will occur, but it may be of interest as an introduction to give some of the more important connections in detail and simply to mention others of less importance.

The largest chemical industry using wood as a raw material is the pulp and paper industry. In 1922 about 7,000,000 cords of pulpwood were consumed in the United States and Canada, of which 65 per cent was used by the chemical processes. This industry is also very particular about the species of wood it uses. Pulpwood consists chiefly of two or three species; spruce, balsam, hemlock, and aspen make up 80 per cent of the total.

There are several important chemicals which are produced largely from wood by the wood distillation process - acetic acid, acetone, methanol, and formaldehyde. Recently

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Read at meeting of American Institute of Chemical Engineers, Washington, D.C., Dec. 1923.

the first two have been made from other sources, but wood is still the only commercial source of methanol and formaldehyde. Over 1,000,000 cords of hardwood are used yearly for distillation.

The tanning industry depends largely on the forests for tanning agents. Chestnut wood and hemlock, chestnut oak, and tan oak barks are the native forest products most used for tanning; but others are imported, such as quebracho, mangrove, and myrobolans; and still others of lesser importance are collected in this country, such as sumach and osage orange.

Turpentine and rosin are forest products of great importance in the chemical industry. This country produces about three-fourths and consumes nearly one-half the world's total of these products, which are so important in the paint, varnish, soap, and paper industries.

There are also a large number of less important chemical forest products: cedar wood oil, cedar leaf oil and other needle oils; Canada balsam and Oregon balsam; various medicinal barks, such as cascara sagrada and slippery elm; galactan, which has become a commercial source of mucic acid; and various sugars and gums. Our temperate zone forests are not so prolific in these miscellaneous chemical products as are the tropical forests, but the list just given is impressive and other products may be developed.

Wood as a structural material is also of importance in chemical industry, since it is resistant to the chemical action of weak acids and can be used in tanks, towers, and pipes in contact with chemicals which might corrode iron or steel.

Enough has been said to show the value of the forests to the chemical industries and to account for the interest which the chemical industries should take in forest conservation. It might be of interest to describe some of the methods employed by the Forest Service in promoting forest conservation. Instead of giving the silvicultural side of the program it is probably better, with an audience of chemical engineers, to show how chemical research is used in forest conservation.

Some time ago it was decided that increased efficiency in the utilization of forest products was a very important part of any forestry program, and the "Products" work of the Forest Service was the result. The work on better utilization of wood is divided into seven principal fields, the purpose of each being:

Research for Better Utilization

1. The use of less wood in construction work through more complete knowledge of strength and grades and design.

2. Reduction of waste or degrade through better methods of production, particularly in drying.

3. Higher yields (or in general greater efficiency) in chemical processes using wood as a raw material.

4. Use of new and less costly species.

5. Use of waste wood instead of more valuable wood.

6. Waste wood utilization by new methods.

7. Prevention of decay in wood.

The first two of these fields are purely mechanical and physical, and no attempt will be made to elaborate on the research which has been carried on to bring about these results although it has been important and successful. In all the other fields chemical research has been employed (in the last two of them chemical research exclusively), and some examples of the work and the results will be given.

In order to bring about the utilization of new, cheap, and plentiful species as substitutes for the more expensive species a fairly complete study has been made of the paper making qualities of nearly a hundred American woods. The yields and quality of the pulp made by the soda, sulphate, and sulphite processes have been determined, and in several cases satisfactory substitutes have been found for the common pulpwood, spruce, in making both sulphite and sulphate pulps.

Many hardwoods have been distilled to find the yields of acetic acid, methanol, and charcoal; and it has

been found that several species give as good yields as the beech, birch, and maple which had been used almost exclusively since the foundation of the industry in this country.

The development of the use of waste wood in place of wood prepared especially for a certain process is more a process of education and persuasion than one of research. For instance, the use of spruce slabs by pulp mills in place of the round or split pulpwood is difficult to develop, although from the chemical standpoint the slabs are certainly as good. It has been shown by experimental work that the slabs (including bark) of certain species of hardwood give at least as much alcohol and acid as the heartwood. Such information ought to lead to the utilization of more mill waste.

Certain finely divided forms of waste, such as sawdust, can not be used the same as cordwood for chemical purposes even though they have the same chemical composition. For instance, sawdust can not be destructively distilled in the same kind of apparatus that will handle cordwood and a chemical pulp made from sawdust is not suitable for paper making on account of the shortness of the fibers. These examples show the need of investigation to adapt waste materials to other uses.

The production of higher yields in any chemical process using wood as a raw material is a direct saving in

wood consumption, and many of our investigations have been directed toward this end. In the hardwood distillation industry a modification of firing procedure has been introduced as a result of our experiments, which gives 5 to 10 per cent increase in the yields of the chemical products. More recent work has shown the possibility of increasing the alcohol yields by at least 50 per cent by treating the wood with as little as 0.5 per cent sodium carbonate before distillation. This has not yet been tried on a commercial scale, but arrangements have been made for trials in the near future.

Many refinements in cooking procedure have been studied to increase the yield or efficiency in soda, sulphite and sulphate pulp manufacture. It has been shown that in all the chemical processes for making pulp the rate of heating the digester has a great influence on the yield of pulp, which can be increased from 10 to 20 per cent by following a regular heating schedule. A large number of experiments have shown the effect of time of heating, concentration of chemicals, temperature, and pressure. An insight has been gained into the chemical reactions proceeding during the pulping operation, transforming this operation from a "rule of thumb" to a precise chemical basis. The manifold uses of wood pulp continually create new problems in the study of the pulping process, especially as wood

is the only cheap and plentiful raw material at present which can be used for paper making.

The previously mentioned researches have been in connection with industries already in commercial operation. In order to increase the utilization of certain kinds of waste, such as softwood sawdust, it has been necessary to develop new methods or further to investigate suggested methods which had not been sufficiently successful to use large quantities of waste. Much new information has been gained on the processes of making cattle food and ethyl alcohol from softwoods by hydrolysis with dilute acids, and it is hoped that the work now under way may result in the successful commercial manufacture of both of these products from wood waste.

Some of our experimental work has resulted in the utilization of waste wood from western larch, through the extraction of the galactan found in this wood and the manufacture from it of galactose and mucic acid. In a similar manner our studies of the coloring matter in the wood of osage orange have led to the successful commercial manufacture of a dyeing and tanning extract from waste wood of that species. Although waste utilization methods have been found for certain species like these, it has been because extractives of unusual character were found in the wood. We have not yet developed any chemical method of waste utilization suitable for all forms and species.

By far the greatest preventable destruction of wood products is decay. The prevention of decay is therefore potentially the most important factor in lessening the drain on the forests. The preservation of wood against decay has been a commercial process for many years, but there is still much to learn about the process. Much wood is still used without preservative treatment in situations favorable to decay.

Tests of preservatives and methods of injecting them into wood have been studied. Some species are comparatively easy to impregnate, while others resist the penetration of preservatives and it has been necessary to develop treating methods for each species which will give the penetration and absorption of preservatives necessary to provide adequate protection.

Railway ties, posts, poles and piling, dock and other structural timbers are coming more and more to be treated with preservatives to prevent decay. Marine structures are also being treated to prevent borer attack. Service test records on installations of both treated and untreated timbers are kept. Periodic inspections add to the bulk of authentic information, making it of great value in estimating the probable durability of structures and in specifying the preservative or method of application best suited for a given construction.

Coal-tar creosote and zinc chloride are the two most widely used preservatives, but others have been found that are good for special uses.

These brief statements give a general view of the importance and the varied character of the chemical work of the Forest Service. One other point not touched upon should be emphasized. Although our research work is industrial research and industrial application is always the end in view yet, like other large industrial research organizations, we have not hesitated to devote a considerable proportion of our effort to fundamental scientific research. We have felt that the more information we have on the general subject of the chemical composition of wood, the more rapid and successful will be our specific investigations on chemical methods for utilizing wood. We have therefore kept in progress projects on the chemical composition of wood and especially one on the analysis of species, both heartwood and sapwood, and we now have a compilation of data on this subject far in advance of that available elsewhere. These data have not only been of much indirect and more or less intangible assistance to our more practical research projects or to industrial operations, but have directly resulted in commercial application in the cases of western larch and osage orange woods, as already mentioned.

In connection with the general study of wood preservatives we have also carried on considerable fundamental scientific work on such seemingly trivial and impractical subjects as "Why and how does a wood preservative preserve?" and "What is the relation between chemical composition, physical characteristics, and preservative value?" Here again the information obtained has not only been of indirect assistance to the industry, but lately, when a new preservative for very special use was required, it was possible from theoretical considerations alone to recommend a new, cheap, and satisfactory mixture.

It is understood that this meeting was held in Washington largely for the purpose of studying the chemical work of the government departments and that these papers are mainly preparation for later inspections of the laboratories. Unfortunately, you will not be able to do this in the case of the work just described since our chemical research is carried on at the Forest Products Laboratory, Madison, Wisconsin.